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NASA TECH BRIEF

Fluoride Coatings Make Effective Lubricants in Molten Sodium Environment

The problem: To devise a solid-film coating that will provide effective lubrication against sliding friction in molten sodium (liquidus range from approximately 208° to 1620°F) and other severe environments at high and low temperatures. Molten sodium combines a number of favorable mechanical and thermodynamic properties which make it an important heat-transfer fluid in power-generation systems. Although molten sodium itself can provide good lubrication between metal-to-metal bearing surfaces, the surfaces may be essentially in solid contact during transient startup periods. Under these conditions, high friction, wear, and gross seizure are apt to occur.

The solution: Coat the bearing surfaces with a thin film of the mixed fluorides of calcium and barium.

How it's done: The coatings are prepared by thoroughly mixing different proportions of the reagent-grade powdered fluorides in distilled water (approximately 1 cc of water per gram of powder) in a high-speed blender. These mixtures are then sprayed to a thickness ranging from 0.001 inch to 0.002 inch onto carefully cleaned and lightly sand-blasted bearing surfaces. The bearings are heated to approximately 160°F before and during spraying to ensure rapid evaporation of the water. The coated bearings are then fired in a reducing atmosphere of dry hydrogen at temperatures ranging from 1550° to 1950°F for periods from 6 to 10 minutes, depending on the composition of the spray mixture.

For experimental evaluation, lubricant films formed from different mixtures of the fluorides were applied to friction disks of a nickel–chromium alloy. This alloy has good mechanical properties and is compatible with molten sodium at temperatures up to approximately 1500°F. The coated disks were subjected to controlled frictional loads and rotational speeds in a number of environments, including molten sodium, hydrogen, air, and vacuum, at prescribed temperatures in a specially designed apparatus. The test results indicate that the fused calcium fluoride–barium fluoride coatings are satisfactory solid lubricants in molten sodium with respect to friction, wear, and chemical stability. At 1000°F and a sliding velocity of 2000 feet per minute, the friction coefficients ranged from 0.15 to 0.20. X-ray diffraction tests revealed no evidence of chemical attack on these coatings after exposure of 2 to 3 hours to sodium at 1000°F.

Notes:

1. When sliding velocities are sufficiently high, calcium fluoride–barium fluoride and calcium fluoride–lithium fluoride films provide effective lubrication in a vacuum (10^{-8} mm Hg) at room temperature. Friction coefficients were less than 0.2 at sliding velocities greater than 1000 feet per minute, but increased to 0.36 at 450 feet per minute.
2. A number of the fluoride films are effective lubricants in air at temperatures from 85° to 1200°F, in hydrogen (10% hydrogen–90% nitrogen) at

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temperatures from 75° to 1500°F, in liquid oxygen, and in liquid fluorine.

3. The most apparent limitation of the fluoride coatings is that at low sliding velocities they exhibit high friction coefficients at temperatures below approximately 500°F.
4. The fluoride coatings should find application as solid lubricants at various temperatures in vacuum and in oxidizing or reducing atmospheres.
5. Further information concerning this innovation is given in NASA TN D-2348, "Fused Fluoride Coatings as Solid Lubricants in Liquid Sodium, Hydrogen, Vacuum and Air," by Harold E. Sliney, Thomas N. Strom, and Gordon P. Allen, August 1964, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151. Inquiries may also be directed to:

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Patent status:

No patent action is contemplated by NASA.

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